Conceptual design of clean electricity generation units deploying recovery technologies from waste coal-based fuel feedstock

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Waste coal or sterile coal is a low-value residue associated to the coal extraction, mining activity and coal washing. According to the type and origin of the coal bed configuration, waste coal production can mainly vary on quantity, calorific value and presence of sulphur and other compounds. In addition, the potential availability of sterile coal in some areas, Spain for instance, is apparently significant and its contribution to the local power generation would be of interest playing a significant role.

Even noticeable improvements achieved by the application of energy efficiency measures, global energy demand is expected to double by 2050, in particular electricity that currently accounts for about 40% of the total energy consumed. These are clearly challenging times for the utility sector in general but for the electric utility sector in particular. Crucial decisions about fuel and waste deployment, generation and delivery of cleaner and greener power to set a common satisfactory energy agenda have to be arranged now, and it has to be taken based on a deep evaluation of alternatives, definition of conceptual schemes and implementation technology viable but concerning about health, global warming, security of supply and cost of energy.

Fossil fuels, coal and gas, accounts by far the basis of electricity generation and will remain playing a key role in the global energy mix. Coal is the most intensive resource use to generate electricity and heat but also use for the industry to produce chemicals and materials.

This study proposes four (4) alternatives of electricity generation facility from waste coal-based feedstock, including the analysis of additional portions of another fuels and waste, like coal, urban organic solid waste and biomass, in order to define potential valuable fuels to feed the power generation facilities proposed and improve energy recovery of waste coal.

Basically, two (2) processes are selected, combustion and gasification, to recover the energy content on the waste coal-based fuel feedstock. Regarding combustion, pulverised coal and circulating fluidised bed boilers are evaluated, incorporating process units to remove SO_2 and CO_2 content (post-combustion process), decrease NO_x and also produce H_2SO_4 with high value in the fertiliser manufacturing industry. Regarding gasification, entrained-flow gasifier integrated in a combined cycle is selected (IGCC), incorporating process units to concentrate sulphur compounds and CO_2, increase H_2 production, remove H_2S and CO_2 content (pre-combustion process), and decrease NOx compounds. The conceptual design models are defined through the integration of different units and deployment of available technology. The evaluation of the conceptual basic design according to the power output set for a maximum waste coal or sterile contribution, establishes that rates over 95% H_2S and 90% CO_2 removal can be achieved.

The conceptual design of the different units, the assessment and evaluation of the different configurations, will come in useful, supporting decision-making groups to select the most convenient form of using waste coal, coal and other types of organic waste, to mainly produce electricity with no emission, especially greenhouse gas emission, acid gases like carbon dioxide and sulphur compounds.

Keywords: waste coal; clean coal technologies; CO2 capture; electricity generation; power generation; gasification